

[Type of Document] Specification

[Title of the Invention] Radio communication apparatus

[Scope of Claims for Patent]

[Claim 1] A radio communication apparatus that is applied to a
5 radio communication system and communicates with a partner radio
communication apparatus in the radio communication system using
usable one or plural channels, comprising:

a reception processing unit that, in receiving input reception
signals of the plural channels of the radio communication system,
10 respectively, measures reception states of input reception signals of the
respective channels, generates local channel reception information of
the respective channels based on a result of the measurement, and
applies reception processing to the input reception signals to generate
decoded signals;

15 a MAC unit that, when data is transmitted using two or more
channels, generates transmission frames for the respective channels
using transmit data;

a transmission processing unit that generate radio signals
including the respective transmission frames; and

20 a channel information processing unit that generates local
feedback information based on the respective pieces of local channel
reception information and inserts the generated local feedback
information into the one or plural radio signals, wherein

the radio communication apparatus transmits radio signals
25 including the local feedback information.

[Claim 2] The radio communication apparatus according to claim 1, wherein the channel information processing unit generates the local feedback information based on the respective pieces of local channel reception information and resource information that is a
5 processing load of the MAC unit.

[Claim 3] The radio communication apparatus according to claim 1 or 2, further comprising a selector that, when the channel information processing unit inserts local feedback information, selects radio signals, into which the local feedback information is inserted,
10 based on the respective pieces of channel reception information.

[Claim 4] The radio communication apparatus according to any one of claims 1 to 3, wherein

when transmission source feedback information inserted by the partner radio communication apparatus is inserted in the respective
15 input reception signals, the reception processing unit extracts the transmission source feedback information,

the MAC unit determines transmission systems and transmission speeds based on the extracted transmission source feedback information, and
20 the transmission processing unit generates radio signals based on the transmission systems and the transmission speeds.

[Claim 5] The radio communication apparatus according to any one of claims 1 to 3, wherein

when transmission source feedback information inserted by the
25 partner radio communication apparatus is inserted in the respective

input reception signal, the reception processing unit extracts the transmission source feedback information,

the MAC unit extracts transmission source addresses included in the decoded signals at the time of reception and extracts destination
5 addresses of transmit data at the time of transmission, and

the channel information processing unit generates a local feedback table, in which the local channel reception information, the extracted transmission source feedback information, and the extracted transmission source addresses are stored in association to one another,
10 at the time of reception, searches through the local feedback table with the destination addresses as keywords at the time of transmission to generate the local feedback information based on local channel reception information corresponding to transmission source addresses for which the transmission source addresses stored in the local
15 feedback table and the destination addresses coincide with each other, and determines transmission systems and transmission speeds based on transmission source feedback information corresponding to the transmission source addresses for which the transmission source addresses stored in the local feedback table and the destination
20 addresses coincide with each other, and

the transmission processing unit generates radio signals based on the transmission systems and the transmission speeds.

[Claim 6] A radio communication apparatus that is applied to a radio communication system and communicates with a partner radio
25 communication apparatus in the radio communication system using

usable one or plural channels, comprising:

a reception processing unit that, in receiving input reception signals of every plural channels of the radio communication system, respectively, measures reception states of input reception signals of the
5 respective channels, generates local channel reception information of the respective channels based on a result of the measurement, and applies reception processing to the input reception signals to generate decoded signals;

a MAC unit that, when data is transmitted using two or more
10 channels, generates local feedback information based on the respective pieces of local channel reception information, further generates transmission frames for the respective channels using transmit data, and inserts the local feedback information into one or plural transmission frames; and

15 a transmission processing unit that generates radio signals including the respective transmission frames and transmits the generated radio signals.

[Claim 7] The radio communication apparatus according to claim 6, wherein the MAC unit generates the local feedback information
20 based on the respective pieces of local channel reception information and resource information that is a processing load.

[Claim 8] The radio communication apparatus according to claim 6 or 7, wherein

when transmission source feedback information inserted by the
25 partner radio communication apparatus is inserted in the decoded

signals, the MAC unit extracts the transmission source feedback information and determines transmission systems and transmission speeds based on the extracted transmission source feedback information, and

- 5 the transmission processing unit generates radio signals based on the transmission systems and the transmission speeds.

[Claim 9] The radio communication apparatus according to any one of claims 6 to 8, wherein

- at the time of reception, the MAC unit extracts transmission
10 source addresses included in the decoded signals and generates a local channel reception information table in which the local channel reception information and the extracted transmission source addresses are stored in association with each other, and

- at the time of transmission, when data to be transmitted is a
15 feedback frame for notifying local feedback information, the MAC unit extracts destination addresses in the feedback frame, searches through the local channel reception information table with the extracted destination addresses as keywords, generates the local feedback information based on local channel reception information corresponding
20 to transmission source addresses for which the transmission source addresses stored in the local channel reception information table and the destination addresses coincide with each other, and inserts the generated local feedback information into the feedback frame.

- [Claim 10] The radio communication apparatus according to
25 claim 9, wherein

in generating the local channel reception information table, the MAC unit further stores a time of day of the generation, when information stored in the local channel information table is used, compares a present time of day and the time of day of the generation, when a difference between the present time of day and the time of day of the generation is within a predetermined range as a result of the comparison, generates the local feedback information based on the local channel reception information of the local channel information table, and when a difference between the present time of day and the time of day of the generation exceeds the predetermined range, does not generate the local feedback information.

[Claim 11] The radio communication apparatus according to any one of claims 6 to 8, wherein

when the decoded signal is a feedback frame from the partner radio communication apparatus, the MAC unit extracts a transmission source address included in the decoded signal, extracts transmission source feedback information included in the feedback frame, and generates a transmission source feedback information table in which the transmission source address and the transmission source feedback information are stored in association with each other, and

at the time of transmission, the MAC unit extracts a destination address from data to be transmitted, searches through the transmission source feedback information table with the extracted destination address as a keyword, and determines a transmission system and a transmission speed based on transmission source feedback information

corresponding to a transmission source address for which the destination address and the transmission source address stored in the transmission source feedback information table coincide with each other.

5 [Claim 12] The radio communication apparatus according to claim 11, wherein

 in generating the transmission source feedback information table, the MAC unit further stores a time of day of the generation, when information stored in the transmission source feedback information
10 table is used, compares a present time of day and the time of day of the generation, when a difference between the present time of day and the time of day of the generation is within a predetermined range as a result of the comparison, determines a transmission system and a transmission speed based on the transmission source feedback
15 information of the transmission source feedback information table, and when a difference between the present time of day and the time of day of the generation exceeds the predetermined range, determines a transmission system and a transmission speed decided in advance as a transmission system and a transmission speed.

20 [Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a radio communication apparatus that uses plural channels simultaneously to perform mutual
25 communication, and in particular to a radio communication apparatus

that notifies a partner radio communication apparatus of a reception state of a channel to be used and selects an appropriate communication system and communication speed.

[0002]

5 [Prior Art]

In recent years, an increase in communication speed is demanded in a radio communication apparatus as well. Therefore, in a radio communication system, the increase in communication speed is realized by increasing a transmission capacity using plural channels.

10 [0003]

In a conventional technology for realizing the increase in communication speed using plural channels, plural channels are allocated and secured in advance in a path between a specific communication unit system and a specific terminal unit system, in which
15 a wide transmission band is required, to perform communication on the plural channels (see, for example, Patent Document 1).

[0004]

Patent Document 1: Japanese Patent Application Laid-Open
No. 2002-135304

20 [0005]

[Problems to be Solved by the Invention]

However, in the case of radio communication, a communication state changes depending on environments like obstacles and weather conditions (e.g., rainy weather). In addition, in the case of mobile
25 communication, a communication state always changes with time due

to movements. In the conventional technology, a technique for selecting transmission systems and transmission speeds suitable for communication states in performing communication on plural channels is not disclosed. Therefore, there is a problem in that it is impossible to select a transmission system and a transmission speed suitable for a communication state in each channel.

[0006]

For example, in the conventional technology, when a modulation system with a high transmission speed is adopted, although a transmission speed is increased, communication cannot be performed in a place where a state of a transmission channel is bad and retransmission requests increase, which results in decline in throughput. In addition, when a modulation system in which communication is possible even when a state of a transmission channel is bad, a communication speed falls, and an advantage of increasing a transmission capacity using plural channels is reduced.

[0007]

The invention has been devised in view of the above, and it is an object of the invention to provide a radio communication apparatus that can select transmission systems and transmission speeds corresponding to respective channels in performing mutual communication using plural channels.

[0008]

[Means to Solve the Problems]

In order to achieve the above objects, a radio communication

apparatus according to the present invention is applied to a radio communication system and communicates with a partner radio communication apparatus in the radio communication system using usable one or plural channels, and the radio communication apparatus

5 includes a reception processing unit that, in receiving input reception signals of the plural channels of the radio communication system, respectively, measures reception states of input reception signals of the respective channels, generates local channel reception information of the respective channels based on a result of the measurement, and

10 applies reception processing to the input reception signals to generate decoded signals; a MAC unit that, when data is transmitted using two or more channels, generates transmission frames for the respective channels using transmit data; a transmission processing unit that generate radio signals including the respective transmission frames;

15 and a channel information processing unit that generates local feedback information based on the respective pieces of local channel reception information and inserts the generated local feedback information into the one or plural radio signals, wherein the radio communication apparatus transmits radio signals including the local

20 feedback information.

[0009]

According to the present invention, a reception processing unit generates local channel reception information based on reception states of input reception signals of respective channels, a channel

25 information processing unit attempts to generate local feedback

information based on the local channel reception information generated by the reception processing unit, insert the generated local feedback information into radio signals, and transmit the radio signals.

[0010]

5 [Embodiments of the Invention]

Exemplary embodiments of a radio communication apparatus according to the present invention will be hereinafter explained in detail with reference to the attached drawings.

[0011]

10 Fig. 1 is a schematic diagram of a structure of a radio communication system to which a radio communication apparatus in the invention is applied. The radio communication system, to which the radio communication apparatus in the invention is applied, includes plural (four in this case; however, the number is irrelevant the number
15 of channels and the number of radio communication apparatuses in a radio communication area) radio communication apparatuses 1 to 4 that performs mutual communication via a radio area 5 that uses plural (three in this case) channels. It is assumed that all the radio communication apparatuses 1 to 4 have the same functions.

20 [0012]

Note that the channels of this radio communication apparatus indicate communication paths that are set for performing communication at, for example, a frequency, time, a code, and a space (Multi Input Multi Output (MIMO)).

25 [0013]

First embodiment

A first embodiment of the invention will be explained using Fig.

2. Fig. 2 is a block diagram of a structure of transmission and reception functions of a radio communication apparatus 1 according to the first embodiment in the invention. The radio communication apparatus 1 according to the first embodiment in the invention includes a reception processing unit 10 that has plural (three in this case) reception channel processing units 110 to 130 corresponding to the number of channels usable by the apparatus itself, a Media Access Control (MAC) unit 20, a channel information processing unit 30, and a transmission processing unit 40 that has plural (three in this case) transmission channel processing units 410 to 430 corresponding to the number of channels usable by the apparatus itself.

[0014]

15 The reception channel processing unit 110 receives an input reception signal of a channel corresponding to the reception channel processing unit 110 and applies synchronization processing, demodulation processing, and decoding processing to the input reception signal. In addition, the reception channel processing unit 20 110 measures reception levels of input reception signals in the respective channels. Then, the reception channel processing unit 110 generates local channel reception information based on the measured reception levels or Receive Signal Strength Indication (RSSI) and reception channel processing internal information that is physical 25 resources like a memory, a buffer, and a Central Processing Unit (CPU)

and state resources of a control signal and the inside of the memory according to processing of the channel itself. The reception channel processing unit 110 judges whether feedback information is included in the input reception signal. The feedback information is information
5 related to overall resources like reception state information of the channel and states of the memory, the CPU, and the buffer.

[0015]

The reception channel processing units 120 and 130 have the same function as the reception channel processing unit 110 and apply
10 the same processing as the reception channel processing unit 110 to channels corresponding to the reception channel processing units 120 and 130, respectively.

[0016]

At the time of a reception operation, the MAC unit 20 controls
15 the reception channel processing units 110 to 130 serving as physical communication media and applies processing like protocol conversion and frame conversion to respective decoded signals to generate reception frames. In addition, the MAC unit 20 judges whether feedback information is included in the respective decoded signals.

20 [0017]

At the time of a transmission operation, the MAC unit 20 applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted from an upper layer to generate transmission frames of respective channels. In addition, the
25 MAC unit 20 exchanges resource information with the channel

information processing unit 30 and determines transmission systems and transmission speeds for the respective channels based on feedback information of the respective channels from a transmission source that is inputted from the channel information processing unit 30.

5 [0018]

The channel information processing unit 30 mutually exchanges resource information, which is the physical resources such as the memory, the buffer, and the CPU and the state resources of a control signal and the inside of the memory, with the MAC unit 20 to perform a reception operation and generates local feedback information based on
10 respective pieces of local channel reception information inputted from the reception channel processing units 110 to 130 and the resource information. The local feedback information may be all determined pieces of the local channel reception information and the resource
15 information or may be information that is selected out of the local channel reception information and the resource information and aggregated every time.

[0019]

In addition, the channel information processing unit 30 judges
20 whether the respective pieces of transmission source feedback information inputted from the reception channel processing units 110 to 130 or the MAC unit 20 have identical contents. As the judgment, for example, when Cyclic Redundancy Check (CRC) is used, the channel information processing unit 30 discards the pieces of transmission
25 source feedback information for which the CRC indicates an error and

adopts only the pieces of transmission source feedback information for which the CRC is normal, or adopts the pieces of transmission source feedback information that have identical contents and are largest in number, or measures a Carrier/Noise ratio (C/N) and a

- 5 Desired/Undesired ratio (D/U) for each channel and adopts the transmission source feedback information of a channel having highest C/N and D/U, or synthesizes weighting according to probability with respect to all pieces of the information and adopts the respective pieces of transmission source feedback information based on the weighting.

10 [0020]

The channel information processing unit 30 discards the transmission source feedback information of a wrong channel as a result of the judgment and extracts feedback information of respective channels from the accurate transmission source feedback information.

15 [0021]

The transmission channel processing unit 410 selects a transmission system and a transmission speed of a channel based on transmission control information. Then, based on the selected transmission system and transmission speed, the transmission channel processing unit 410 applies encoding processing and modulation processing to the transmission frame inputted from the MAC unit 20 and the local feedback information inputted from the channel information processing unit 30 to generate a radio signal.

[0022]

25 The transmission channel processing units 420 and 430 have

the same function as the transmission channel processing unit 410 and apply the same processing as the transmission channel processing unit 410 to channels corresponding to the transmission channel processing units 420 and 430, respectively.

5 [0023]

Next, operations of the radio communication apparatus will be explained. First, a reception operation will be explained. The reception channel processing units 110 to 130 receive input reception signals in the corresponding channels, respectively, apply demodulation
10 processing and decoding processing to the input reception signals, and output decoded signals to the MAC unit 20. At the same time, the reception channel processing units 110 to 130 measure reception levels of the input reception signals in the respective channels and generate local channel reception information based on the measured respective
15 reception levels and reception channel processing internal information. Then, the reception channel processing units 110 to 130 output the generated local channel reception information to the channel information processing unit 30. In addition, the reception channel processing units 110 to 130 judge whether feedback information is
20 included in the input reception signals and, when feedback information is included in the input reception signals, output the feedback information in the input reception signals to the channel information processing unit 30 as transmission source feedback information.

[0024]

25 The MAC unit 20 applies the processing such as the protocol

conversion and the frame conversion to the decoded signals inputted from the reception channel processing units 110 to 130, respectively, generates reception frames, and outputs the reception frames to the upper layer. In addition, the MAC unit 20 judges whether feedback information is included in the respective decoded signals and, when
5 feedback information is included in the decoded signals, outputs the feedback information in the decoded signals to the channel information processing unit 30 as transmission source feedback information.

[0025]

10 Next, a transmission operation will be explained. The channel information processing unit 30 generates local feedback information based on the respective pieces of local channel reception information inputted from the reception channel processing units 110 to 130 and the resource information, copies the generated local feedback information,
15 and outputs the local feedback information to the transmission channel processing units 410 to 430. At the same time, the channel information processing unit 30 extracts accurate transmission source feedback information from the respective pieces of transmission source feedback information inputted from the reception channel processing
20 units 110 to 130 or the MAC unit 20 and outputs the extracted feedback information of the respective channels to the MAC unit 20.

[0026]

The MAC unit 20 applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted
25 from the upper layer to generate transmission frames of the respective

channels. Then, the MAC unit 20 outputs the generated respective transmission frames to the transmission channel processing units 410 to 430. In addition, the MAC unit 20 exchanges the resource information with the channel information processing unit 30 and
5 determines transmission systems and transmission speeds of the respective channels based on the feedback information of the respective channels from a transmission source that is inputted from the channel information processing unit 30. Then, the MAC unit 20 outputs the transmission systems and the transmission speeds
10 determined for the respective channels to the transmission channel processing units 410 to 430 as transmission control information.

[0027]

The transmission channel processing units 410 to 430 select transmission systems and transmission speeds of the channels based
15 on the respective pieces of transmission control information inputted from the MAC unit 20. Then, based on the selected transmission systems and transmission speeds, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation processing to the transmission frames inputted from the MAC unit 20
20 and the local feedback information inputted from the channel information processing unit 30 to generate radio signals. Then, the transmission channel processing units 410 to 430 output the generated radio signals.

[0028]

25 In this way, in the first embodiment, the reception channel

processing units 110 to 130 generate local channel reception information based on reception states of respective input reception signals, and the channel information processing unit 30 generates local feedback information based on the local channel reception information generated by the reception channel processing units 110 to 130 and the resource information and inserts the generated local feedback information into a radio signal to be transmitted on a channel used for transmission. Thus, it is possible to notify a partner radio communication apparatus of states of respective channels such that the partner radio communication apparatus can select transmission systems and transmission speeds suitable for the states of the respective channels.

[0029]

In addition, the MAC unit 20 determines transmission systems and transmission speeds of the respective channels based on respective pieces of local feedback information inserted by the partner radio communication apparatus (transmission source feedback information of the apparatus itself). This makes it possible to select transmission systems and transmission speeds of the respective channels, and retransmission requests can be controlled to improve throughput and reduce communication delays.

[0030]

Moreover, since local feedback information is inserted into all channels to be used, it is possible to learn feedback information of the respective channels if one channel among plural channels can be

received.

[0031]

Second embodiment

A second embodiment of the invention will be explained using
5 Fig. 3. In the first embodiment, local feedback information is inserted
into all channels. In the second embodiment, channels into which
local feedback information is inserted are limited, whereby a radio band
necessary for notifying the local feedback information of a partner radio
communication apparatus is reduced to realize an increase in a radio
10 capacity.

[0032]

Fig. 3 is a block diagram of a structure of transmission and
reception functions of a radio communication apparatus according to
the second embodiment in the invention. In the radio communication
15 apparatus 1 according to the second embodiment, a selector 50 is
added to the radio communication apparatus 1 according to the first
embodiment shown in Fig. 2. Components having the same functions
as those in the first embodiment will be denoted by the identical
reference numerals, and a redundant explanation will be omitted.

20 [0033]

The selector 50 determines a channel, on which local feedback
information generated by the channel information processing unit 30 is
transmitted, based on respective pieces of local channel reception
information inputted from the reception channel processing units 110 to
25 130. The local channel reception information is information such as

the C/U and the D/U. The selector 50 judges communication states of respective channels from these pieces of local channel reception information and selects a channel having a best communication state. In other words, from the local channel reception information of the
5 respective channels, the selector 50 judges which channel should be used to transmit local feedback information such that the local feedback information can be notified to a partner radio communication apparatus at a high probability. Note that a selection method is not limited to this and, for example, a specific number of specific channels may be used
10 without using channel information.

[0034]

Next, operations of the radio communication apparatus according to the second embodiment in the invention will be explained. First, a reception operation will be explained. The reception channel
15 processing units 110 to 130 receive input reception signals in the corresponding channels, respectively, apply the demodulation processing and the decoding processing to the input reception signals, and output decoded signals to the MAC unit 20. At the same time, the reception channel processing units 110 to 130 generate local channel
20 reception information based on reception levels of respective channels and reception channel processing internal information. Then, the reception channel processing units 110 to 130 output the generated local channel reception information to the channel information processing unit 30 and the selector 50. In addition, when feedback
25 information is included in the input reception signals, the reception

channel processing units 110 to 130 output the feedback information in the input reception signals to the channel information processing unit 30 as transmission source feedback information.

[0035]

5 The MAC unit 20 applies the processing such as the protocol conversion and the frame conversion to the decoded signals inputted from the reception channel processing units 110 to 130, respectively, generates reception frames, and outputs the reception frames to the upper layer. In addition, the MAC unit 20 judges whether feedback
10 information is included in the respective decoded signals and, when feedback information is included in the decoded signals, outputs the feedback information in the decoded signals to the channel information processing unit 30 as transmission source feedback information.

[0036]

15 Next, a transmission operation will be explained. The channel information processing unit 30 generates local feedback information based on the respective pieces of local channel reception information inputted from the reception channel processing units 110 to 130 and resource information and outputs the generated local feedback
20 information to the selector 50. In addition, the channel information processing unit 30 outputs feedback information of the respective channels for the transmission source feedback information, which is inputted from the reception channel processing units 110 to 130 or the MAC unit 20, to the MAC unit 20.

25 [0037]

The MAC unit 20 applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted from the upper layer to generate transmission frames of the respective channels. Then, the MAC unit 20 outputs the generated respective transmission frames to the transmission channel processing units 410 to 430. In addition, the MAC unit 20 exchanges the resource information with the channel information processing unit 30 and determines transmission systems and transmission speeds of the respective channels based on the feedback information of the respective channels from a transmission source that is inputted from the channel information processing unit 30. Then, the MAC unit 20 outputs the transmission systems and the transmission speeds determined for the respective channels to the transmission channel processing units 410 to 430 as transmission control information.

15 [0038]

The selector 50 determines a channel, on which the local feedback information generated by the channel information processing unit 30 is transmitted, based on the respective pieces of local channel reception information inputted from the reception channel processing units 110 to 130. Then, the selector 50 outputs the local feedback information to a transmission channel processing unit corresponding to the determined channel.

[0039]

The transmission channel processing units 410 to 430 select transmission systems and transmission speeds of the channels based

on the respective pieces of transmission control information inputted from the MAC unit 20. Then, based on the selected transmission systems and transmission speeds, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation processing to the transmission frames inputted from the MAC unit 20 to generate radio signals. In that case, when the local feedback information is inputted from the selector 50, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation processing to the transmission frames and the local feedback information to generate radio signals. Then, the transmission channel processing units 410 to 430 output the generated radio signals.

[0040]

In this way, in the second embodiment, the selector 50 determines a channel, on which local feedback information generated by the channel information processing unit 30 is transmitted, based on the respective pieces of local channel reception information inputted from the reception channel processing units 110 to 130 to limit channels into which the local feedback information is inserted. Thus, it is possible to reduce radio bands in which the local feedback information is notified to a partner radio communication apparatus and realize an increase in a radio capacity.

[0041]

Note that, although the selector 50 is independently provided in the second embodiment, the function of the selector 50 may be

included in the channel information processing unit 30.

[0042]

Third embodiment

A third embodiment of the invention will be explained using Fig.

5 4. Fig. 4 is a block diagram of a structure of transmission and reception functions of a radio communication apparatus according to the third embodiment in the invention. In the radio communication apparatus 1 according to the third embodiment, a MAC unit 20a is provided instead of the MAC unit 20 of the radio communication
10 apparatus 1 according to the first embodiment shown in Fig. 1, and a channel processing controller unit 60 (channel information processing unit described in patent-claims) is provided instead of the channel information processing unit 30.

[0043]

15 The MAC unit 20a applies the processing such as the protocol conversion and the frame conversion to decoded signals inputted from the reception channel processing units 110 to 130, respectively, generates reception frames, and outputs the reception frames to an upper layer. At the same time, the MAC unit 20a outputs address
20 information (transmission source addresses) in the respective reception frames to the channel processing controller unit 60. In addition, the MAC unit 20a applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted from the upper layer to generate transmission frames of the respective channels.

25 [0044]

The channel processing controller unit 60 belongs to a physical layer and performs timing control and feedback processing control for the reception processing unit 10 and the transmission processing unit 40 belonging to the same physical layer. The channel processing controller unit 60 identifies a transmission source address of a partner radio communication apparatus from the respective pieces of address information or input reception signals of the respective channels and creates a local feedback table in which transmission source addresses and respective pieces of channel reception information are associated with each other. More specifically, the channel processing controller unit 60 generates a local feedback table in which transmission source addresses and the respective pieces of local channel reception information of the reception channel processing units 110 to 130 are associated with each other. In addition, the channel processing controller unit 60 determines transmission systems and transmission speeds of the respective channels based on the respective pieces of transmission source feedback information inputted from the reception channel processing units 110 to 130. Then, the channel processing controller unit 60 registers the determined transmission systems and transmission speeds in the local feedback table for the respective channels in association with the transmission source addresses. Note that it is also possible that transmission source feedback information is registered in association with transmission source addresses in the local feedback table, and a transmission system and a transmission speed are determined at the time of transmission based on this

transmission source feedback information.

[0045]

Next, operations of the radio communication apparatus according to the third embodiment in the invention will be explained.

5 First, a reception operation will be explained. The reception channel processing units 110 to 130 receive input reception signals in the corresponding channels, respectively, apply the synchronization processing, the demodulation processing, and the decoding processing to the input reception signals, and output decoded signals to the MAC
10 unit 20a. At the same time, the reception channel processing units 110 to 130 generate local channel reception information based on reception levels of the respective channels and reception channel processing internal information. Then, the reception channel processing units 110 to 130 output the generated local channel
15 reception information to the channel processing controller unit 60. In addition, the reception channel processing units 110 to 130 judge whether feedback information is included in the input reception signals and, when feedback information is included in the input reception signals, output the feedback information in the input reception
20 signals to the channel information processing unit 30 as transmission source feedback information.

[0046]

The MAC unit 20a applies the processing such as the protocol conversion and the frame conversion to the decoded signals inputted
25 from the reception channel processing units 110 to 130, respectively,

generates reception frames, and outputs the reception frames to the upper layer. In addition, the MAC unit 20a outputs transmission source addresses in the respective reception frames to the channel processing controller unit 60.

5 [0047]

The channel processing controller unit 60 identifies a transmission source address of a partner radio communication apparatus from the respective transmission source addresses inputted from the MAC unit 20a or the input reception signals of the respective
10 channels and creates a local feedback table in which the transmission source addresses and respective pieces of local channel reception information are associated with each other.

[0048]

Next, a transmission operation will be explained. The MAC
15 unit 20a applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted from the upper layer to generate transmission frames of the respective channels. Then, the MAC unit 20a outputs the generated respective transmission frames to the transmission channel processing units 410 to 430. In addition, the
20 MAC unit 20a outputs destination addresses in the respective transmission frames to the channel processing controller unit 60.

[0049]

The channel processing controller unit 60 searches through the local feedback table with the destination addresses as keywords and
25 determines local feedback tables transmission systems [Translator's

comment: "local feedback tables transmission systems" should be amended to "local feedback information transmission systems"], and transmission speeds of the respective channels. When data is transmitted to the transmission source addresses at the time when the local feedback information table is generated, it is sufficient to search through the local feedback table with the destination addresses of the transmission frames generated by the MAC unit 20a as keywords. The channel processing controller unit 60 outputs the local feedback information, the transmission systems, and the transmission speeds, which are determined for the respective channels, to the corresponding channel transmission channel processing unit 410 to 440, respectively.

-[0050]-

The transmission channel processing units 410 to 430 select transmission systems and transmission speeds of the channels based on the respective transmission systems and transmission speeds inputted from the channel processing controller unit 60. Then, based on the selected transmission systems and transmission speeds, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation processing to the transmission frame inputted from the MAC unit 20a and the local feedback information inputted from the channel processing controller unit 60 to generate radio signals. Then, the transmission channel processing units 410 to 430 output the generated radio signals.

[0051]

In this way, in the third embodiment, the MAC unit 20a notifies

the channel processing controller unit 60 of the transmission source addresses and the destination addresses, the channel processing controller unit 60 generates a local feedback table associating the transmission source addresses and local feedback information, and at
5 the time of transmission, the channel processing controller unit 60 generates local feedback information based on the local feedback table and determines transmission systems and transmission speeds of the respective channels. Thus, it is possible to perform processing with the processing closed in a physical layer and to cope with system
10 change of a MAC layer or higher layers easily.

[0052]

In addition, since it is possible to perform processing with the processing closed in a physical layer, for example, in the case of a system returning response frames in response to transmission frames,
15 it is possible to insert local feedback information into part of the response frames. The local feedback information is notified to a partner radio communication apparatus in shortest time, which makes it possible to perform high-speed feedback processing even when a fluctuation state in a transmission channel is intense and deterioration
20 of radio signals in the respective channels is severe.

[0053]

Fourth embodiment

A fourth embodiment of the invention will be explained using Fig. 5. Fig. 5 is a block diagram of a structure of transmission and
25 reception functions of the radio communication apparatus 1 according

to the fourth embodiment in the invention. In the radio communication apparatus 1 according to the fourth embodiment, the channel information processing unit 30 of the radio communication apparatus 1 according to the first embodiment shown in Fig. 2 is removed, and a
5 MAC unit 20b is provided instead of the MAC unit 20. Components having the same functions as those in the first embodiment will be denoted by the identical reference numerals, and a redundant explanation will be omitted.

[0054]

10 At the time of a reception operation, the MAC unit 20b extracts feedback information included in decoded signals inputted from the reception channel processing units 110 to 130, respectively. Then, the MAC unit 20b creates a local feedback information table in which local channel reception information of the respective channels and the
15 extracted feedback information are associated with the transmission source addresses. In addition, the MAC unit 20b applies the processing such as the protocol conversion and the frame conversion to the decoded signals inputted from the reception channel processing units 110 to 130, respectively, generates reception frames, and output
20 the reception frames to the upper layer.

[0055]

At the time of a transmission operation, the MAC unit 20b applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted from the upper layer to
25 generate transmission frames of the respective channels. In that case,

the MAC unit 20b inserts local feedback information into the respective transmission frames based on the local feedback information table and determines transmission systems and transmission speeds of the respective channels.

5 [0056]

Next, operations of the radio communication apparatus according to the fourth embodiment in the invention will be explained. First, a reception operation will be explained. The reception channel processing units 110 to 130 receive input reception signals in the
10 corresponding channels, respectively, and apply the synchronization processing, the demodulation processing, and the decoding processing to the input reception signals to generate decoded signals. At the same time, the reception channel processing units 110 to 130 measure reception levels of the input reception signals in the respective
15 channels and generate local channel reception information based on the measured respective reception levels and reception channel processing internal information. The reception channel processing units 110 to 130 output the respective decoded signals and the local channel reception information to the MAC unit 20b.

20 [0057]

The MAC unit 20b extracts feedback information from the decoded signals inputted from the reception channel processing units 110 to 130, respectively. Then, the MAC unit 20b generates a local feedback information table in which the local channel reception
25 information for the respective channels and the extracted feedback

information are associated with transmission source addresses. In addition, the MAC unit 20b applies the processing such as the protocol conversion and the frame conversion to the decoded signals, from which the feedback information is extracted, generates reception
5 frames, and outputs the reception frames to the upper layer.

[0058]

Next, a transmission operation will be explained. The MAC unit 20b applies the processing such as the protocol conversion and the frame conversion to a transmission frame inputted from the upper layer
10 to generate transmission frames of the respective channels. In generating the transmission frames of the respective channels, the MAC unit 20b searches through the local feedback information table with destination addresses as keywords and extracts local channel reception information of the respective channels. Then, the MAC unit
15 20b generates local feedback information based on the local channel reception information corresponding to the respective channels and inserts the generated local feedback information into predetermined places of the transmission frames of the respective channels. In addition, the MAC unit 20b searches through the local feedback
20 information table with the destination addresses as keywords and extracts feedback information of the respective channels corresponding to the destination addresses. Then, the MAC unit 20b determines transmission systems and transmission speeds based on the feedback information corresponding to the respective channels and outputs the
25 determined transmission systems and transmission speeds to the

transmission channel processing units 410 to 430 as transmission speed information.

[0059]

The transmission channel processing units 410 to 430 select
5 transmission systems and transmission speeds of the channels based on the respective pieces of transmission control information inputted from the MAC unit 20b. Then, based on the selected transmission systems and transmission speeds, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation
10 processing to the transmission frames inputted from the MAC unit 20 and the local feedback information inputted from the channel information-processing unit 30 to generate radio signals. Then, the transmission channel processing units 410 to 430 output the generated radio signals.

15 [0060]

In this way, in the fourth embodiment, the MAC unit 20b generates the local feedback information table in which the local channel reception information for the respective channels and the extracted feedback information are associated with the transmission
20 source addresses and inserts the local feedback information into appropriate places in the transmission frames. Thus, it is possible to notify a partner radio communication apparatus of the local feedback information without having means for inserting the local feedback information anew and to reduce decline in efficiency of the radio
25 communication apparatus.

[0061]

In addition, since it is possible to notify local feedback information with a structure closed in a MAC layer and determine transmission systems and transmission speeds, it is possible to apply
5 the radio communication apparatus to a system in a different physical layer that uses plural channels.

[0062]

Moreover, since it is possible to perform processing with the processing closed in a MAC layer, for example, in the case of a system
10 returning response frames in response to transmission frames, it is possible to insert local feedback information into part of the response frames, reduce radio-bands in which the local feedback information is notified to a partner radio communication apparatus, and realize an increase in a radio capacity. The local feedback information is notified
15 to the partner radio communication apparatus in shortest time, which makes it possible to perform high-speed feedback processing even when a fluctuation state in a transmission channel is intense and deterioration of radio signals in the respective channels is severe.

[0063]

20 Note that the transmission frames into which the local feedback information is inserted may be all transmission frames of the respective channels, or channels on which the local feedback information is transmitted may be determined based on the respective pieces of local channel reception information.

25 [0064]

Fifth embodiment

A fifth embodiment of the invention will be explained using Figs. 6 to 8. Fig. 6 is a block diagram of a structure of transmission and reception functions of the radio communication apparatus 1 according to the fifth embodiment in the invention. The radio communication apparatus 1 according to the fifth embodiment includes a MAC unit 20c instead of the MAC unit 20b of the radio communication apparatus 1 according to the fourth embodiment shown in Fig. 5.

[0065]

At the time of reception, the MAC unit 20c extracts transmission source addresses from decoded signals inputted from the reception channel-processing units 110 to 130, respectively, and creates a local feedback information table in which the extracted transmission source addresses and local channel reception information notified from the reception channel processing units 110 to 130 are associated with each other. In addition, when the respective decoded signals are feedback frames for notifying a partner radio communication apparatus of local feedback information, the MAC unit 20c extracts transmission source addresses in the feedback frames and creates a transmission source feedback information table in which transmission feedback information for the respective channels in the feedback frames and the extracted transmission source addresses are associated with each other. When the decoded signals are normal frames, the MAC unit 20c applies the processing such as the protocol conversion and the frame conversion to the decoded signals, generates reception frames, and outputs the

reception frames to an upper layer.

[0066]

At the time of transmission, when transmission frames are feedback frames, the MAC unit 20c generates local feedback

5 information based on a local channel reception information table and inserts the generated local feedback information into the feedback frames. The MAC unit 20c determines transmission systems and transmission speeds of the respective channels based on the transmission source feedback information table.

10 [0067]

Next, operations of the radio communication apparatus 1 according to the fifth embodiment in the invention will be explained with reference to flowcharts in Figs. 7 and 8. First, a reception operation will be explained with reference to the flowchart in Fig. 7. The

15 reception channel processing units 110 to 130 receive input information of channels corresponding to the reception channel processing units 110 and 130, respectively, and apply the synchronization processing, the demodulation processing, and the decoding processing to the input information to generate decoded signals. At the same time, the
20 reception channel processing units 110 and 130 measure reception levels of input reception signals of the respective channels and generate local channel reception information based on the measured respective reception levels and reception channel processing internal information (steps S100 and S110). The reception channel processing
25 units 110 to 130 output the respective decoded signals and the local

channel reception information to the MAC unit 20c.

[0068]

The MAC unit 20c extracts transmission source addresses from the decoded signals inputted from the reception channel processing units 110 to 130, respectively (step S120). Then, the MAC unit 20c creates a local feedback information table in which the extracted transmission source addresses and the respective pieces local channel reception information notified from the reception channel processing units 110 to 130 are associated with each other (step S130).

10 [0069]

The MAC unit 20c judges whether the respective decoded signals are feedback frames for notifying a partner radio communication apparatus of local feedback information (step S140). When the respective decoded signals are feedback frames, the MAC unit 20c performs predetermined feedback frame processing such as extraction of transmission source feedback information from the decoded signals (step S150). Then, the MAC unit 20c creates a transmission source feedback information table in which the extracted transmission source feedback information and transmission source addresses extracted from the decoded signals are associated with each other (step S160).

[0070]

When the respective decoded signals are normal frames, the MAC unit 20c performs normal frame processing of applying the processing such as the protocol conversion and the frame conversion to the respective decoded signals, generating reception frames, and

outputting the reception frames to the upper layer (step S170).

[0071]

Next, a transmission processing will be explained with reference to the flowchart in Fig. 8. The MAC unit 20c extracts a destination address from a transmission frame inputted from the upper layer (step S200). Then, the MAC unit 20c judges whether the transmission frame is a feedback frame (step S210). When the transmission frame is a feedback frame, the MAC unit 20c searches through the local feedback information table with the extracted destination address as a keyword and extracts local channel reception information of the respective channels. Then, the MAC unit 20c generates local feedback information from the extracted local channel reception information of the respective channels (step S220). Then, the MAC unit 20c inserts the generated local feedback information into the feedback frame to generate a feedback frame (step S230).

[0072]

The MAC unit 20c searches through the transmission source feedback information table with the extracted destination address as a keyword and extracts transmission source feedback information of the respective channels corresponding to the destination address. Then, the MAC unit 20c determines transmission systems and transmission speeds based on the feedback information corresponding to the respective channels and outputs the determined transmission systems and transmission speeds to the transmission channel processing units 410 to 430 as transmission speed information (step S240).

[0073]

The transmission channel processing units 310 to 430 select transmission systems and transmission speeds of the channels based on respective pieces of transmission control information inputted from the MAC unit 20c. Then, the transmission channel processing units 310 to 340 apply the encoding processing and the modulation processing to the transmission frames inputted from the MAC unit 20c based on the selected transmission systems and transmission speeds to generate radio signals. Then, the transmission channel processing units 310 to 340 output the generated radio signals (step S250).

[0074]

When the transmission frames are normal frames, the MAC unit 20c performs normal frame processing of applying the processing such as the protocol conversion and the frame conversion to the transmission frames and generating transmission frames of the respective channels (step S260). In addition, the MAC unit 20c searches through the transmission source feedback information table with the extracted destination address as a keyword and extracts transmission source feedback information of the respective channels corresponding to the destination address. Then, the MAC unit 20c determines transmission systems and transmission speeds based on feedback information corresponding to the respective channels and outputs the determined transmission systems and transmission speeds to the transmission channel processing units 410 to 430 as transmission speed information (step S240).

[0075]

The transmission channel processing units 410 to 430 select transmission systems and transmission speeds of the channels based on the respective pieces of transmission control information inputted from the MAC unit 20c. Then, based on the selected transmission systems and transmission speeds, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation processing to the transmission frames inputted from the MAC unit 20c to generate radio signals. Then, the transmission channel processing units 410 to 430 output the generated radio signals (step S250).

[0076]

In this way, in the fifth embodiment, since a dedicated frame for transmitting local feedback information is provided, it is possible to notify a partner radio communication apparatus of feedback information of respective channels without requiring a change with respect to an existing system and with simplified control and processing. It is possible to select transmission systems and transmission speeds suitable for the respective channels.

[0077]

Note that, when the dedicated frame for transmitting local feedback information is transmitted periodically, it is necessary to transmit the dedicated frame at a short period with respect to fluctuation in a transmission channel. Therefore, throughput declines. In addition, when the local feedback information cannot be transmitted, reliability of the local feedback information may decline to cause a

communication error. In such a case, it is sufficient that the reception channel processing units 110 to 130 detect fluctuation in the transmission channel, and the MAC unit 20c judges the fluctuation in the transmission channel to determine a transmission interval of the
5 dedicated frame for transmitting the local feedback information.

[0078]

Sixth embodiment

A sixth embodiment of the invention will be explained using Figs. 9 and 10. Fig. 9 is a block diagram of a structure of transmission and
10 reception functions of a radio communication apparatus according to the sixth embodiment in the invention. The radio communication apparatus 1 according to the sixth embodiment includes a MAC unit 20d instead of the MAC unit 20c according to the fifth embodiment shown in Fig. 6. Components having the same functions as those in
15 the fifth embodiment will be denoted by the identical reference numerals, and a redundant explanation will be omitted.

[0079]

At the time of a reception operation, the MAC unit 20d has a function of also registering a creation time of day in creating a local
20 feedback information table and a transmission source feedback information table in addition to the same function as at the time of the reception operation of the MAC unit 20c of the fifth embodiment.

[0080]

At the time of a transmission operation, the MAC unit 20d
25 applies the processing such as the protocol conversion and the frame

conversion to a transmission frame inputted from an upper layer to generate transmission frames of respective channels. In that case, the MAC unit 20d inserts local feedback information into the respective transmission frames based on the local feedback information table and, at the same time, determines transmission systems and transmission speeds of the respective channels.

[0081]

Operations of the radio communication apparatus 1 according to the sixth embodiment in the invention will be explained with reference to a flowchart in Fig. 10. First, a reception operation will be explained. The reception channel processing units 110 to 130 receive input information of channels corresponding to the reception channel processing units 110 to 130, respectively, and apply the synchronization processing, the demodulation processing, and the decoding processing to the input information to generate decoded signals. At the same time, the reception channel processing units 110 to 130 measure reception levels of input reception signals of the respective channels and generate local channel reception information based on the measured respective reception levels and reception channel processing internal information. The reception channel processing units 110 to 130 output the respective decoded signals and the local channel reception information to the MAC unit 20d.

[0082]

The MAC unit 20d extracts transmission source addresses from the decoded signals inputted from the reception channel processing

units 110 to 130, respectively. Then, the reception channel processing units 110 to 130 create a local feedback information table in which the extracted transmission source addresses, the respective pieces of local channel reception information notified from the reception channel

5 processing units 110 to 130, and present times of day are associated to one another.

[0083]

The MAC unit 20d judges whether feedback information is included in the respective decoded signals and, when feedback
10 information is included in the respective decoded signals, extracts the feedback information in the decoded signals. The MAC unit 20d creates a transmission source feedback information table in which the transmission source feedback information extracted from the decoded signals, the extracted transmission source addresses, and present
15 times of day are associated to one another.

[0084]

The MAC unit 20d applies the processing such as the protocol conversion and the frame conversion to the respective decoded signals, generates reception frames, and outputs the reception frames to an
20 upper layer.

[0085]

Next, a transmission operation will be explained with reference to the flowchart in Fig. 10. The MAC unit 20d extracts a destination address from a transmission frame inputted from the upper layer (step
25 S300).

[0086]

The MAC unit 20d searches through the local feedback information table with the extracted destination address as a keyword and extracts local channel reception information of the respective channels and creation times of day of the local channel reception information (step S310). The MAC unit 20d calculates a difference between the extracted creation times of day and the present time of day. Then, the MAC unit 20d judges whether a calculation result is within a reference value decided in advance (step S320). When the calculation result is within the reference value decided in advance, the MAC unit 20d inserts the local feedback information into predetermined places of the transmission frames from the extracted local channel reception information of the respective channels (step S330). When the calculation result exceeds the reference value decided in advance, the MAC unit 20d judges that the local channel reception information of the respective channels is different from present states of the respective channels because time has passed since the local channel reception information was created and does not insert the feedback information in the transmission frames. The MAC unit 20d applies the processing such as the protocol conversion and the frame conversion to the transmission frames to generate transmission frames of the respective channels. Then, the MAC unit 20d outputs the generated respective transmission frames to the transmission channel processing units 410 to 430.

25

[0087]

The MAC unit 20d searches through the transmission source feedback information table with the extracted destination address as a keyword and extracts transmission source feedback information of the respective channels and creation times of day of the transmission source feedback information (step S340). The MAC unit 20d calculates a difference between the extracted creation times of day and the present time of day. Then, the MAC unit 20d judges whether a calculation result is within a reference value decided in advance (step S350). When the calculation result is within the reference value decided in advance, the MAC unit 20d determines transmission systems and transmission speeds of the respective channels based on the extracted transmission source feedback information (step S360). When the calculation result exceeds the reference value decided in advance, the MAC unit 20d judges that the local channel reception information of the respective channels is different from present states of the respective channels because time has passed since the local channel reception information was created and determines to use transmission systems and transmission speeds decided in advance (step S370). The MAC unit 20d notifies the transmission channel processing units 410 to 430 of the determined transmission systems and transmission speeds.

[0088]

The transmission channel processing units 410 to 430 select transmission systems and transmission speeds of the channels based on the respective pieces of transmission control information inputted

from the MAC unit 20d. Then, based on the selected transmission systems and transmission speeds, the transmission channel processing units 410 to 430 apply the encoding processing and the modulation processing to the transmission frames inputted from the MAC unit 20d to generate radio signals. Then, the transmission channel processing units 410 to 430 output the generated radio signals (step S380).

[0089]

In this way, in the sixth embodiment, in creating a local channel reception information table and a transmission source feedback information table, creation times of day of the tables are registered, and the creation times of day and a present time of day are compared to judge reliability concerning whether the local channel reception information and the transmission source feedback information are used. Thus, it is possible to use information suitable for temporal fluctuation in a state of a transmission channel and to reduce a wasteful communication fee.

[0090]

Note that, in the sixth embodiment, the case in which the local feedback information is inserted into transmission frames is explained as an example. However, it is needless to mention that it is possible to apply the case to the first to the fifth embodiments by creating a local feedback information table in which transmission addresses, respective pieces of local channel reception information, and present times of day are associated to one another and a transmission source feedback information table in which transmission source feedback information,

extracted transmission source addresses, and present times of day are associated to one another.

[0091]

[Effects due to the Invention]

5 As explained above, according to the radio communication apparatus according to the invention, a reception processing unit generates local channel reception information based on reception states of input reception signals of respective channels; and a channel information processing unit generates local feedback information based on the local channel reception information generated by the reception processing unit, inserts the generated local feedback information into radio signals, and transmits the radio signals. Thus, it is possible to notify a partner radio communication apparatus of states of the respective channels, and the partner radio communication apparatus can select transmission systems and transmission speeds suitable for the states of the respective channels.

[Brief Description of the Drawings]

[Fig. 1] A schematic diagram of a structure of a radio communication system to which a radio communication apparatus in the invention is applied.

[Fig. 2] A block diagram of a structure of transmission and reception functions of a radio communication apparatus according to a first embodiment in the invention.

[Fig. 3] A block diagram of a structure of transmission and reception functions of a radio communication apparatus according to a

second embodiment in the invention.

[Fig. 4] A block diagram of a structure of transmission and reception functions of a radio communication apparatus according to a third embodiment in the invention.

5 [Fig. 5] A block diagram of a structure of transmission and reception functions of a radio communication apparatus according to a fourth embodiment in the invention.

[Fig. 6] A block diagram of a structure of transmission and reception functions of a radio communication apparatus according to a
10 fifth embodiment in the invention.

[Fig. 7] A flowchart for explaining a reception operation of the radio communication apparatus according to the fifth embodiment in the invention.

[Fig. 8] A flowchart for explaining a transmission operation of
15 the radio communication apparatus according to the fifth embodiment in the invention.

[Fig. 9] A block diagram of a structure of transmission and reception functions of a radio communication apparatus according to a sixth embodiment in the invention.

20 [Fig. 10] A flowchart for explaining a transmission operation of the radio communication apparatus according to the sixth embodiment in the invention.

[Description of Signs]

1, 2, 3, 4 Radio communication apparatus

25 10 Reception processing unit

20, 20a, 20b, 20c, 20d MAC unit

30 Channel information processing unit

40 Transmission processing unit

50 Selector

5 60 Channel processing controller unit

110, 120, 130 Reception channel processing unit

410, 420, 43[Translator's comment: "43" should be corrected to "430".]

 Transmission channel processing unit